DISTRIBUTION, CHARACTERIZATION AND UTILIZATION OF PROBLEM SOILS IN MALAYSIA–A COUNTRY REPORT

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Introduction

In Malaysia, peat, acid sulfate soils, soil on sandy beach deposits, saline soils and soils on ultrabasic rocks are commonly referred to as problem soils. These soils are being actively studied to optimize their utilization and productivity for suitable crop establishment. This report will only deal with the distribution, characterization and utilization of peat, acid sulfate soil and sandy beach deposits, as these soils constitute the major portion of the problem soils in Malaysia.

1 Peat

1) Distribution

There are about 2.5 million hectares of peat areas in Malaysia accounting for about 7% of the total land area (Tay, 1969; Joseph *et al.*, 1974), of which 1.0 million hectares are in Peninsular Malaysia (Leamy and Panton, 1966) and the rest in Sabah and Sarawak (Anderson, 1964; Thomas and Allen, 1965). Their distribution by states is shown in Table 1 and Fig. 1.

Peat soils occur in the poorly drained inland depressions along the coastal area. In some areas the peat may extent landward along the valley bottoms. Despite their abundance, these peat deposits have remained relatively undeveloped compared to the mineral soils. Large areas of peat in Malaysia are found in the regional agricultural development areas such as West Johore Project (more than 50% of the project area is covered by peat). These large tracts of peat have been largely left under forest cover and developed only to a limited extent for agriculture.

2) Characteristics

Malaysian peat is oligotrophic – low in mineral content and acid in reaction, pH in the natural state being less than 4, usually between 3.5 – 3.8. These peats which have often less than 10% ash are formed from forest debris and consist of a mass of semi-decomposed woody material, the colour of the peaty matrix being dark brown. The most important variable is the depth of peat which varies from 0.6 to 9.1m. In general peat in Malaysia is over 1.5m in depth and in Peninsular Malaysia peat overlies marine alluvium/gleyed clays in the west coast and sand in many parts of the east coast.

Malaysian peat usually holds large amounts of moisture. Its water-holding capacity can vary from 15 – 20 times its own dry weight. Undrained it is always waterlogged, the water table being at the soil surface. With excessive drainage, peat can undergo "irreversible drying". Upon drainage, peat also undergoes considerable shrinkage due to consolidation as well as oxidation. Draining too rapidly or initially to great depth will cause a marked shrinkage of the exposed peat and subsidence of the soil.

Roots and tree stumps are particularly abundant in peat layer. Recognizable rootlets, leaves and twigs at various stages of decomposition may also be seen in a peat profile.

Peninsular Malaysian peat is coarse, woody or fibrous with slippery or soapy feeling. It has a high organic matter content which is in the region of 80% or more and a high loss on ignition

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Table 1 Distribution of peat in Malaysia (after Coulter, 1957; Anderson 1964; Thomas and Allen, 1965)

Distribution by states	Hectares
Johore	216,000
Pahang	285,000
Selangor	182,000
Perak	69,000
Trengganu	46,000
Kelantan	11,000
Negeri Sembilan	4,000
Sarawak	1,466,000
Sabah	86,000
Total	2,365,000

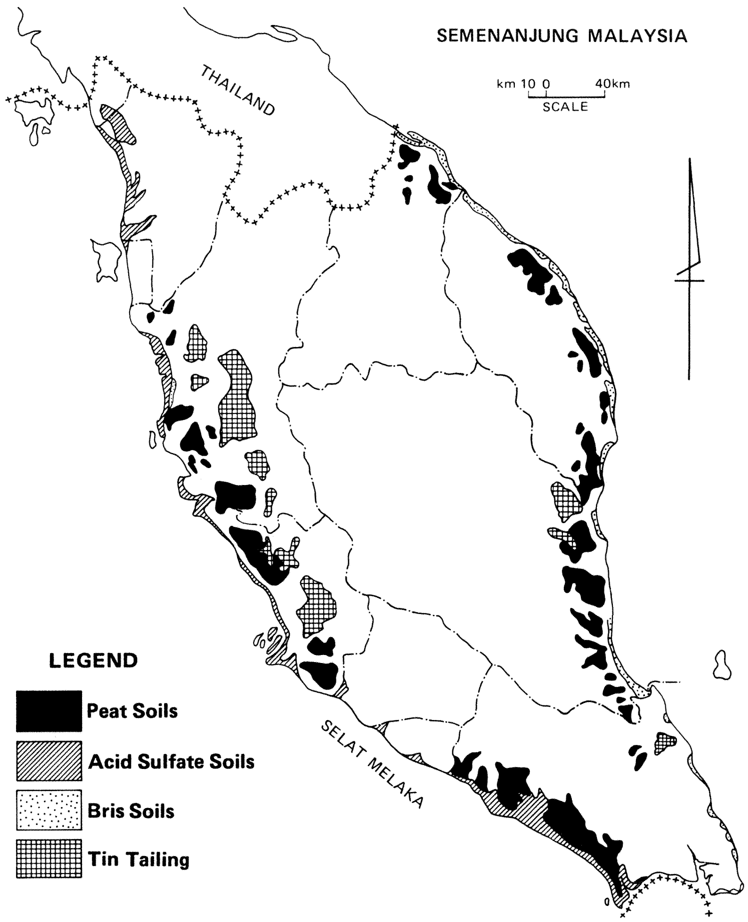

Fig. 1(a) Distribution of peat, acid sulfate and potential acid sulfate, Bris and tin-tailing soils in Peninsular Malaysia.

which usually exceeds 90% (Parberry and Vankatachalam, 1964).

Structurally a peat profile may be considered as amorphous. If well drained, the structure of the soil may become favourable for crop growth.

Peat soils may be considered poor in nutrient contents. They are generally acid in reaction with a pH value ranging from 3.0 to 4.5. This value is partly dependent on the level of the exchangeable hydrogen in the soils. The exchangeable hydrogen of West Malaysian peat is in the range of 88 to 170 meq%. The CEC is also high and the CEC value of peat in South West Johore is 143 meq%.

Peat soils have a low base saturation (Parberry and Venkatachalam, 1964), particularly in calcium and potassium. Available nitrogen and sulfur seem to be very low and this has been shown in the preliminary soil fertility assessment (Tay, 1969).

Micronutrient deficiencies are common in Malaysian peat. The availability of molybdenum is low since peat soils are acidic. In oil palm cultivation, boron deficiency symptoms are frequent on muck and peat soils (William, 1966). In pineapple cultivation deficiency symptoms attributed to lack of zinc (for example "crooknect"), and copper (green die back) have been reported (Joseph *et al.*, 1974).

3) Utilization

In recent years there has been an increasing pressure to develop peat for agriculture, since peat occurs fairly extensively in the easily accessible and highly populated lowlands of Malaysia. The natural forests on peats contain quality timber, therefore sometimes these are exploited for timber.

Early attempts to use peat soils for agriculture on a bigger scale have been initiated in 1938 (Dunsmore, 1957) following the failure of utilizing upland mineral soils for pineapple for a period of more than five years. Attempts also have been made to establish tree crops such as rubber but very little success was reported. Low yields were usually obtained due to poor root anchorage and penetration, subsequent root exposure and falling of the trees as the peat shrank. Emphasis has hitherto been given to grow short-term crops (Chew, 1977). Over the last 40 years pineapple cultivation has been confined exclusively to peat soils. For this purpose about 35,200 hectares of peat land under forest along the southwest coast of Johore were defined as the "potential pineapple area". At present pineapple is the most extensively cultivated crop on peat in Peninsular Malaysia, occupying about 20,000 hectares of peat mainly in Johore (Table 2). The success of pineapple may be ascribed to its adaptability to soil acidity and low fertility. However, due to the limited scope for the expansion of its market, diversification of the agriculture system on peat to include other potential industrial crops has been proposed.

Among tree crops, oil palm acreage on peat has been increasing. So oil palm accounts for the next largest crop planted on peat after pineapple. It is estimated that about 6,000 ha of oil palm is grown on deep peat. Problems of oil palm cultivation on peat include lodging (especially where the peat is deeper than 1.3m), peat yellows (a nutritional problem due to copper deficiency) and lower yields than on the mineral soils. However when the nutritional problems were corrected by adequate liming, fertilizer and with good management practices yields of 20 – 25 ton/ha of fresh fruit bunches have been recorded on 11-year-old palms (Kanapathy, 1978).

Table 2 Distribution and acreage of pineapple (for fresh fruit and canning) on peat in Peninsular Malaysia (1977)

State	Area (ha)		Total
	fresh fruit*	canning**	
Johore	1,940	15,140	17,080
Perak	430	–	430
Selangor	370	–	370
TOTAL			17,880

* FAMA

** MPIB

In properly drained areas, peat soil may provide a good physical medium for a variety of annual crops especially vegetables. Most vegetable farmers in West Selangor practice burning of peat during their land preparation. Burning of peat tends to increase the amount of available phosphate and particularly potash. The pH also increases and this would have a tendency to enhance the decomposition of the peat and increase availability of nitrogen. Burning also was found to increase the availability of Cu, because the compounds which fixed the Cu were destroyed during burning. However, burning of peat is not recommended because the effect of burning will cause rapid loss of peat layer and difficulty in controlling fire on peat.

Among possible annual crops on peat are tapioca, maize, tomatoes, sweet potatoes, sorghum, ginger and water-melon; all of these have been grown on peat. Lowland cabbage and cauliflower are also found to be suitable to be grown on peat soil. Legumes like groundnut and soybeans appear to grow well with proper soil management (Chew *et al.*, 1968a).

Tapioca and banana thrive well on peat while papayas give good yield but their economic life was shown to be shorter due to lodging problems. Coffee seems to do well on peat in spite of having some nutritional problem, and it is grown quite extensively on peat soil in the coastal region of the state of Selangor.

The yield of some promising vegetables and other crops is given in Tables 3 and 4, respectively.

Table 3 Yields of some vegetable crops on peat in West Selangor

Crop	Variety	Yield (ton/ha)		Product
		with liming	after burning[b]	
Tomato	Local	28.6[c]	24.2	fresh fruits
Chilli	C10	18.6[c]	21.0	fresh fruits
	Local	10.0[a]	–	fresh fruits
Green pepper	Local	2.6[a]	–	,,
Brinjal	Local	20.0[a]	–	,,
Okra	Local	15.0[a]	–	,,
Cucumber	Local	25.0[a]	52.0	,,
Luffa	Local	26.0[a]	44.0	,,
Bitter Gourd	Local	14.3[c]	60.0	,,
French bean	Local	11.0[a]	19.0	,,
Long bean	Local	20.0[a]	19.0	,,
Cabbage	Eiyu	–	31.0	fresh fruits
	KK	26.2[c]		
Cauliflower	VS Hybrid	–	9.0	fresh curds
Shallot	Indonesia	–	13.0	dry bulbs
Ginger	Local	34.0[a]	16.0	fresh rhizomes
Radish	Local	20.0[a]	–	fresh roots
Sengkuang	Local	6.6[a]	–	fresh roots

a – Joseph *et al.*, 1974

b – Yields recorded from Project Development trials in West Selangor

c – Experimental yields obtained at MARDI Research Station, Jalan Kebun (Siti Doya, pers. comm.)

Table 4 Yields of some promising crops on peat in West Selangor

Crop	Variety	Yield (ton/ha)	Product
Pineapple	Singapore Spanish	40[a]	fresh fruits
Cassava	Black Twig	49a	fresh tubers
Groundnut	V13	2.2[b]	shelled nuts (dry)
Soybean	S2	1.8[b]	dry grain
Sweet potato	Large white	24[a]	fresh tubers
Sorghum	E178	2.5[a]	dry grain
Maize	Metro	5.3c	dry grain
Virginia tobacco	NC 95	1.0[a]	flue-cured leaves
Colocasia	Keladi China	8.6[b]	fresh tubers
Oil palm	DXP	20 – 25[d]	fresh fruit bunches
Mulberry	'Local'	7.5[a]	dry leaves/annum

a – Joseph *et al.*, 1974; b – Chew, 1971; c – Kanapathy, 1972; d – Kanapathy, 1978.

2 Acid Sulfate Soils

1) Distribution

Acid sulfate soils are commonly found in the coastal regions of Malaysia and they are found in almost all the states of Peninsular Malaysia. The largest area is possibly in the state of Johore (about 250,000 acres). According to Joseph *et al.* (1977), the entire alluvial soils (excluding peat) in the West Johore Agricultural Development scheme are potential acid sulfate soils and acid sulfate soils. In Sarawak, the main areas are found in the Sarawak river delta.

Elsewhere, in Malaysia these acid sulfate soils do not occur in very large continuous areas but rather in isolated patches in otherwise good soils. These patches can range from a few to perhaps several hundred hectares interspersed in non-acid soils. In view of this, it is difficult to estimate the extent of these soils accurately. Their distribution by states is given in Fig. 1.

2) Characteristics

In Malaysia, several acid sulfate soils are recognized and they are mapped as Guar Series, Telok Series, Limau Series, Parit Botak Series, Serkat Series, Sedu and Carey Series. Some profile descriptions and chemical data of the soil series are given in the Appendices I to V.

Acid sulfate soil profiles are usually characterized by an organic layer in the topsoil overlying a clay subsoil in which the acidic horizon occurs. The occurrence of pyrite in the acid sulfate soils

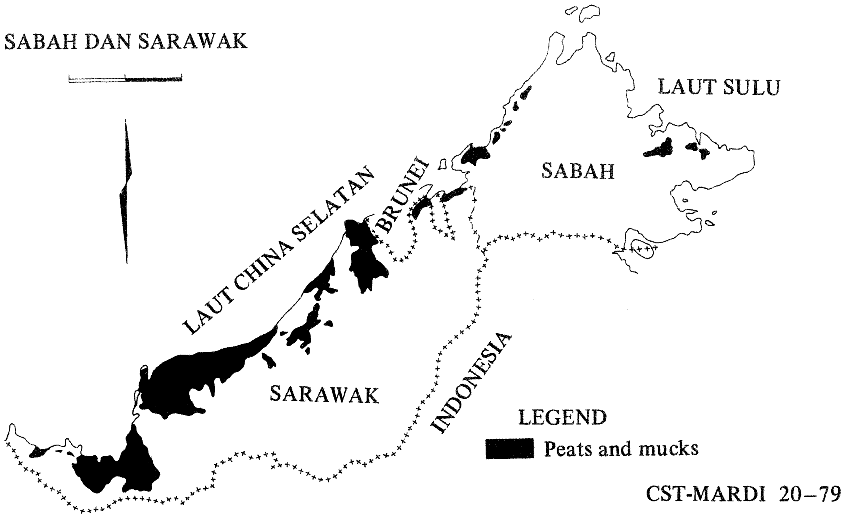

Fig. 1(b) Distribution of peat soils in Sarawak and Sabah, Malaysia. (After Anderson, 1964 and Thomas and Allen, 1965).

in Malaysia can range from the top 25 cm up to 100 cm down the soil profile. Pyrite content varies and the amount can be as high as 10%. The amount of exchangeable aluminum can range from 5 meq/100g to 24 meq/100g of soil (Ting and Zahari, 1976).

On submerging, the water soluble iron can go up to more than 400 ppm, after 2 weeks (Ting, unpublished). The pH of some acid sulfate soils can be as low as 2.7. Different acid sulfate soils vary in their rate of increase of pH after submergence. According to Ting (1977), after 14 weeks of submergence, pH of acid sulfate soils from Batu Berendam (Malacca) increased from 3.60 to 5.58, of soils of Batu Pahat (Johore) from 3.50 to 6.30 and that of Kuala Linggi (Malacca) soil from 3.41 to 4.15. This variation in the changes of pH on submerging acid sulfate soils could be due to the presence of different amounts of organic matter and the amount of reducible iron present in the soils.

3) Utilization

Reclamation and improvement of acid sulfate soils for agriculture are a major problem for which no general and final solution can be proposed. In Malaysia there are still large tracts of marine coastal lands which are uncultivated and which, if opened up for cultivation could pose a management problem. Since these soils vary greatly in the amount and depth at which pyrite occurs, utilization of these soils for crops will therefore differ.

In Malaysia, where the drainage of these soils is poor, they have been used for rice production. The acreage of these soils under rice production is about 25,000 hectares of which a large proportion is in the Muda Scheme. Rubber is also planted extensively in these soils and the acreage is about 25,000 hectares (Kanapathy, 1975). About 30,000 hectares are under coconut, oil palm and other crops like pineapple, coffee, vegetables and tapioca.

Generally, crop performance on acid sulfate soils is poor and sometimes the crops do not grow at all if there are no proper ameliorative measures taken.

(1) Rice

Large acreage of padi is grown on acid sulfate soils in the Muda Scheme in north Peninsular Malaysia and on a smaller scale in other parts of Malaysia. In the rainfed areas where single cropping is practiced, growth of padi on acid sulfate soil is very poor. The plants remain stunted and toxicities due to Fe and Al are common. Rice yield can range from nil to about 1,680 kg/ha. However with the introduction of double cropping especially in the Muda area, rice yield has improved. This could be due to the field being wet most of the year thus preventing oxidation of pyrite which could enhance acidity. With proper fertilization in the double cropping areas, yields as high as 3 to 4 ton/ha are expected from the acid sulfate areas in the Muda scheme.

(2) Rubber

Rubber trees do not grow well on acid sulfate soils even with fertilizer and they could not withstand high water table. In the West Johore Agricultural Development scheme in Malaysia, yield of rubber is about 500 kg/ha/year, which is only about half of that obtained from non acid sulfate soils.

(3) Coconut

Presently, very few published data on the effects of acid sulfate soils on coconut growth and production are available in Malaysia. However from visual observations, it seems that coconut is equally adversely affected as oil palm. The affected palms look very thin and the girth seems irregular. The fronds show a general yellowing and drying and are very few in number. Yield is normally poor.

A preliminary observation trial on the performance of coconut palms grown on acid sulfate soils had been conducted by MARDI on coconut small holdings at Rengit and Batu Pahat areas (MARDI, Annual Report, 1978). In the trial area outside the drainage scheme (outside the bund, towards the coast) the farmers have constructed their own system of bunds, drainage channels and small water control gates, which prevent flooding but allow the sea water to enter the channels at high tide and maintain the water table about 40 cm from the surface where the pyritic layer is around that depth. The annual yield of the nuts in the treatment plots is given in Table 5. Generally the yield of the palm in plots outside the drainage scheme is higher than in the ones inside the drainage scheme. This is possibly attributed to the influence of a high water table which prevents oxidation of the pyrite and thus prevents the increase in acidity. The results (Table 5) also indicate that application of fertilizer and lime manure gives higher yield. However palms growing in soil with high water table and subjected to seawater influence still gave better yield even without fertilizer application when compared to the ones which were freely drained and to which fertilizers had been applied.

Table 5 Average total annual yield of coconut palms in treatment plots outside and inside drainage scheme

Plot	Fertilizer Treatments	Average yield (No. of nuts/acre/yr)			
		1975	1976	1977	Average
Outside drainage scheme (i.e. plots A, B and C)	Control	6,190	6,955	6,890	6,680
	Manured	6,395	7,235	7,227	6,953
Inside drainage scheme	Control	4,538	4,597	4,760	4,589
(i.e. plots D, E and F)	Manured	4,923	4,982	5,234	5,046

(4) Oil palm

Oil palm generally grows poorly on acid sulfate soils if the acidic horizon occurs at a depth of less than 90 cm from the surface. Poor growth and productivity are generally evident when the palms are 5-year-old (Poon, 1977). Hyper-acidity symptoms such as multiple nutrient deficiencies, severe desiccation and premature necroses of normally functional fronds and stunted growth are observed. In the absence of appropriate ameliorative measures, yields are greatly affected and may not exceed 5 ton fresh fruit bunches per hectare per annum (Yeow *et al.* 1977). However with proper fertilization and maintenance of the water table above the pyritic horizon, yields of oil palm increased from 11.44 ton ffb/ha to 15.59 ton ffb/ha (an increase of 36.3%) in the first four-year period after raising the water table. In the next two consecutive four-year periods, yield improved further to an average of 17.79 ton ffb/ha/year.

(5) Other crops

Fruit trees that are tolerant to acidity could be grown on acid sulfate soils. Mango trees show good growth on acid sulfate soils. Jackfruit, pineapple and citrus can also be grown on acid sulfate soils.

Shallow rooted crops like vegetables can be grown successfully on acid sulfate soils.

In Malaysia, however not many acid sulfate areas are opened to fish farming. There could be a potential area for fish and prawn farming in the future when land becomes scarce.

3 Bris

1) Distribution

Bris soils are the sandy marine deposits which occur mainly along the east coast of Peninsular Malaysia and also in the coastal area of Sabah. In the east coast of Peninsular Malaysia these soils form an almost continuous belt varying in width between 180 meter and 8 kilometer from the coast. The estimated total area of Bris soils in Peninsular Malaysia alone is about 155,400 hectares and Thomas (1966) reported that about 40,400 hectares of a similar type of sandy soils exist in Sabah. The distribution of Bris soils in Peninsular Malaysia is shown in Fig. I. Five soil series of Bris have been described namely Baging, Rudua, Jambu, Rompin and Rusila series. Baging and Rompin series are Entisols (Typic Tropopsamment) and have no spodic horizon. Jambu series (Typic Tropohumod) is a Spodosol and the spodic horizon occurs below one and a half meter from the soil surface. Rudua series (Typic Tropohumod) has the spodic layer within one meter of the profile. Rusila series is located in the depression areas and organic layer 0 – 15 cm deep exists on top of the profile.

Due to the almost total lack of clay, these soils have very poor physical and chemical properties. Thus organic matter build up is inhibited and **water-and-nutrient-holding** properties are severely limited. Leaching losses of fertilizers applied are consequently very high. The poor moisture retention properties of these soils create a condition similar to that of the drought-prone semi-arid regions of the world, particularly during the dry months between January and April, when temporary or prolonged drought conditions can occur. The Bris soils experience very high soil temperatures and this inhibits germination and retards crop growth. During the wet monsoon season, however, these areas receive very high rainfall and some areas of Bris soils in the east coast are completely inundated.

2) Characteristics

The particle size distribution of Bris soils is presented in Table 6. In general the composition of sand particles is between 82 and 99% of mainly quartz. Silt contents are within a range of 0.2 to 6.0%. The clay content within 0 – 60 cm depth for Baging, Jambu and Rudua series is less than 1%; for Rompin series the amount of clay in the subsoil is about 12% but in the topsoil only 0.2%.

Since the Bris contain sand particles between 82 and 99% the water retention for this soil is

Table 6 Particle size distribution of Bris soils

Soil series and depth (cm)	SAND Very Coarse 2–1(mm)	Coarse 1–0.5(mm)	Medium 0.5–0.25(mm)	Fine 0.25–0.05(mm)	Total Sand	SILT 0.05–0.002(mm)	CLAY 0.002(mm)
	Percent						
BAGING							
0–15	0	0.56	61.85	35.80	98.21	1.54	0.25
15–30	0	1.02	79.89	18.41	99.32	0.42	0.26
30–45	0	0.64	83.84	19.09	99.57	0.18	0.25
45–60	0	0.90	81.46	17.15	99.51	0.15	0.34
JAMBU							
0–15	0.87	32.70	62.15	2.92	98.64	1.04	0.32
15–30	1.19	28.32	67.36	2.50	99.37	0.32	0.31
30–45	2.27	28.09	66.63	2.44	99.43	0.30	0.27
45–60	2.77	28.77	65.62	2.30	99.46	0.30	0.24
RUDUA							
0–15	0	0.38	21.20	73.98	95.56	4.11	0.33
15–30	0	0.12	20.23	75.92	96.27	3.44	0.29
30–45	0	0.21	25.58	72.17	97.96	1.85	0.19
40–60	0	0.10	25.20	72.57	97.87	1.80	0.33
ROMPIN							
0–30	0	2.70	2.30	94.70	99.70	0.10	0.20
30–60	0	2.30	1.70	78.00	82.00	6.00	12.00
60–90	0	1.70	7.30	74.40	83.40	4.00	12.60

obviously very low. Soil water retention characteristics for Bris soils are shown in Table 7. These data were determined by using pressure plate equipment. In terms of water holding capacity the order is Rompin > Rudua > Baging > Jambu. Such characteristics are related to the particle size distribution (Table 6) and organic matter contents of the soils. Table 7 also shows that in the spodic layer of Rudua series (30 – 45 cm) the amount of moisture retained by the soil was higher than in that above or below it. This was mainly due to the higher amount of organic matter content in the spodic layer.

Wong (1979) and Ives (1967) reported some chemical properties of the Bris soils as shown in Table 8. The percentage of organic carbon and nitrogen in these soils was very low. Total cation exchange capacity was also low except in the spodic layer for Rudua series which was 9.53 meq/ 100 gm; pH values for Baging, Jambu and Rudua series were in the range of 4.4 to 4.3. Rompin series had higher pH values compared to Baging, Jambu and Rudua series.

Table 7 Water retention characteristics of Bris soils

Soil series	Depth (cm)	% moisture by weight at different pressures		
		0.33 bar	1.0 bar	15 bars
BAGING	0–15	5.22	3.83	2.67
	15–30	5.87	4.53	2.23
	30–45	5.27	3.37	1.60
	45–60	4.27	3.17	1.37
JAMBU	0–15	4.50	3.13	2.03
	15–30	3.43	2.22	1.02
	30–45	3.30	2.17	1.28
	45–60	3.18	2.23	1.10
RUDUA	0–15	6.50	4.10	3.03
	15–30	4.80	2.27	1.40
	30–45*	6.60	4.60	2.53
	45–60	4.80	2.83	1.47
ROMPIN	0–15	5.60	5.38	4.18
	15–30	5.50	5.20	4.08
	30–45	7.38	7.12	5.25
	45–60	11.02	10.12	7.37

* Spodic layer

Table 8 Some chemical properties of Bris soils

Soil series and horizon depth (cm)	Carbon %	pH (1:2.5)		Exch. bases meq/100 gm			Mg	Total C E C meq/100gm	Free Iron %	Nitrogen	Reference
		H_2O	KCl	Na	K	Ca					
BAGING											
B1 (12-49)	0.09	4.7	4.3	0.01	0.01	0.05	0.11	0.96	0.55	0.008	Wong (1979)
B2 (49–146)	0.05	4.8	4.3	0.02	0.01	0.04	0.16	1.32	0.55	0.003	
B3 (146–186)	0.02	4.8	4.2	0.01	0.01	0.05	0.31	1.00	0.63	0.002	
JAMBU											
B_{21h} (140–144)	0.44	4.6	4.1	0.02	0.01	0.21	0.02	1.63	0.22	0.015	Wong (1979)
B_{22hir} (144-152)	1.02	4.5	4.4	0.02	0.01	0.18	0.07	5.15	0.84	0.025	
RUDUA											
B_{21h} (33-46)	1.59	4.3	4.0	0.02	0.02	0.03	0.02	9.53	1.15	0.090	Wong (1979)
	0.25	4.4	4.3	0.02	0.01	0.02	0.01	1.52	0.37	0.012	
ROMPIN											
$A3_1$(17–33)	0.53	5.8	4.8	0.09	0.03	0.16	0.11	3.94	–	0.020	Ives (1967)
AB_3(33–68)	0.21	5.4	4.5	0.09	0.03	0.05	0.22	2.23	–	0.010	
BC (68–91)	0.14	5.4	4.1	0.07	0.03	0.05	0.02	1.71	–	0.010	

Table 9 Yields of various crops grown on Bris soils

Crops	Yield	Source of reference
Coconut (with addition of of cattle manure)	7,300 – 2,000 nuts/ha/year	Kho *et al.* (1979)
Cashew (clone C11)	1.5 – 3.0 m ton rawnuts/ha	Chai, (1981), personal communication
Tobacco	1,050 – 2,160 kg of cured leaves/ha	Khairuddin and Kamaruddin (1980)
Cabbage	16,736 – 29,888 kg/ha	Zainuddin (1981), personal communication
Passion fruits	41,814 – 61,938 kg/ha/year	–

3) Utilization

Although the Bris soils are poor in terms of nutrient content and water-holding capacity, few crops have been found to grow satisfactorily on Bris. The crops are coconut (*Cocos nucifera*) cashew (*Anacardium occidentale* L.), tobacco (*Nicotiana tabacum* L.), water melon (*Citrullus vulgaris* L.), cabbage (*Brassica oleracea* L.) and passion fruit (*Passiflora edulis* f. *flaricarpa*). The acreage of tobacco growing on Bris area is about 4,800 hectares while cashew is about 7,120 hectares. Table 9 shows the range of yields for seven different types of crops growing on Bris.

Conclusion

Information available points to the possible establishment of crops like pineapple, coffee and other cash crops on peat soils; oil palm coconuts and rice on acid sulfate and potentially acid sulfate soils; cashew, tobacco and few other cash crops on Bris soils.

A better understanding of the chemical, physical and microbiological properties of these soils has resulted in less failure in crop establishment.

Very little attention has been paid to the development of saline soils for crops in the past. This is changing as land is becoming scarce and more and more areas of saline soils will be brought under cultivation. At present only coconut and some salt-tolerant rice are planted on drained saline soils. Once the salinity is removed these soils have a very high potential for sustained yield for a number of crops including coconut/cocoa and oil palm.

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Appendix (I)

Classification	:	Guar Series Fluventic Dystropept.
Location	:	Guar Chempedak, 1 km from main road (on the right side of Sungei Petani – Alor Star road); 60m from main irrigation canal.
Land form	:	Coastal local depression.
Topography	:	Flat.
Drainage	:	Somewhat very poorly drained.
Vegetation	:	Sedges in abandoned plot.
Parent material	:	Mixed marine alluvium.
Remark	:	Water table at 40 cm at planting time.

Colours are for wet soil.

Ap1	0 – 10 cm	Soft puddled clay.
Ap2	10 – 25 cm	Black (10 YR 2/1) clay; massive; non sticky and non plastic, rich in organic matter; sharp wavy boundary.
B_2Gg	25 – 52 cm	Brown (10 YR 5/3) clay; many fine and medium prominent brownish yellow (10 YR 6/8) mottles mainly around former roots and less on ped surfaces; weak very coarse prismatic structure; sticky and plastics; medium and fine roots common with few large pieces of undecomposed woods; clear wavy boundary.
BCG	522 – 88 cm	Brown (10 YR 5/3) clay; common brown yellow (10 YR 6/8) mottles; weak coarse subangular blocky; sticky but very plastic; few medium and fine roots; many semi-decomposed organic debris; sharp wavy boundary.
CG	88 cm$^+$	Gray (5 Y 5/1) clay; massive; sticky and plastic; abundant organic debris.

	Depth	pH		Exchangeable		% Sulfate-Sulfur (SO_4-S)		
		Fresh	Air-Dry	meq Al^{3+}/100g	meq H^+/100g	Total	2N-HCl soluble	Pyrite
GUAR	Ap1 0–10 cm	5.7	3.25	9.58	2.19	0.19	0.08	0.11
	Ap2 15–25 cm	4.1	3.05	12.68	1.98	0.15	0.08	0.07
	B2Gg 25–52	3.4	3.00	14.52	2.49	0.13	0.09	0.04
	BCG 52–88 cm	3.5	3.20	14.52	2.31	0.13	0.05	0.08
	CG 88+	3.3	3.00	17.04	3.96	0.30	0.10	0.20

Depth	% N	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	% BS
		....	....	meq/100g	....		
Ap1 0–10 cm	0.12	1.65	1.67	0.22	0.27	23.58	14.50
Ap2 15–25 cm	0.16	1.29	1.23	0.26	0.33	23.58	13.87
B2Gg 25–52 cm	0.14	1.36	1.47	0.29	0.16	25	13.28
BCG 52–88 cm	0.14	5.38	1.77	0.39	0.27	26.43	30.08
CG 88+	0.15	3.4	2.17	0.45	0.27	28.93	22.26

Appendix (II)

WEST ESTATE, FIELD 79N/1

Location	:	West Estate, Field 79N/1 Carey Island, Klang
Topography	:	Flat coastal plain
Drainage	:	Imperfect
Water table	:	50 cm
Land use	:	Oil palm
Parent Material	:	Marine alluvium
Classification	:	Typic Sulfaquept

Ap	0 – 3 cm	Very dark grayish brown (10 YR 3/2) clay; friable; moderate coarse angular blocky; abundant fine roots
B2	3 – 12 cm	Dark brown (10 YR 4/3) clay; slightly sticky; moderate coarse angular blocky; many coarse yellow (2.5 Y 7/6) jarosite mottles; gradual wavy boundary.
B3	12 – 50 cm	Dark brown (10 YR 4/3) clay; sticky; structureless massive; few fine roots; common yellow (2.5 Y 7/6) jarosite mottles along old roots and ped faces; clear smooth boundary.
C	50 cm$^+$	Greenish gray (5G Y 5/1) clay; sticky; structureless, massive.

	pH (H_2O)		Conductivity		Exchangeable		% Sulfate-Sulfur (SO_4-S)		
Depth	Fresh	Incubated	Fresh	Incubated	meqAl^{3+} /100g	meq H^+/100g	Total	2N-HCl Soluble	Pyrite
Ap	2.80	2.80	550	950	–	–	0.41	0.35	0.06
B2	2.90	2.65	410	1100	6.68	2.91	0.66	0.60	0.06
B3	3.40	3.05	405	950	7.16	1.89	0.22	0.09	0.13
C	2.75	1.70	1400	10000	11.62	9.01	1.73	0.32	1.41

Depth	% N	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	% BS
		....	....	meq/100g	....		
Ap	0.14	0.48	0.82	0.22	0.54	17.15	12.83
B2	0.15	0.54	1.19	0.32	0.54	18.57	14.75
B3	0.15	0.66	1.69	0.61	0.87	16.79	23.70
C	0.19	1.21	2.62	0.16	0.92	20	25.50

Appendix (III)

Location	:	Coconut Research Station, Parit Botak, Batu Pahat
Grid Ref.	:	L7010 Series 128/201091
Topography	:	Flat coastal plain
Drainage	:	Imperfect
Water table	:	53 cm
Land use	:	Young coconut
Parent material	:	Marine alluvium
Classification	:	Parit Botak Series. Typic Sulfaquept.

Ap	0 – 8	Very dark grayish brown (10 YR 3/2) clay; strong fine sub-angular blocky; friable; many fine and medium roots; clear wavy boundary.
B2	8 – 27 cm	Grayish brown (10 YR 5/2) clay; moderate coarse angular blocky; friable; common coarse distinct strong brown (7.5 YR 5/6) and reddish yellow (7.5 YR 6/8) mottles and few coarse distinct strong brown (7.5 YR 5/6) and reddish yellow (7.5 YR 6/8) mottles and few coarse distinct pale yellow (2.5 Y 8/4) and yellow (2.5 Y 8/6) mottles along root channels; plentiful fine and medium and few coarse roots; gradual wavy boundary.
B3	27 – 41 cm	Grayish brown (10 YR 5/2) clay; weak block to structureless; sticky; common coarse prominent pale yellow (2.5 Y 8/4) and yellow (2.5 Y 8/6) mottles along root channels and ped faces plentiful medium and coarse roots; clear, wavy boundary.
CG	41 – 53 cm+	Blue green clay; few prominent distinct pale yellow (2.5 Y 8/4) and yellow (2.5 Y 8/4) mottles; plentiful medium and coarse roots.

Note : Ap thickness variable: where it is sufficiently thick, the soil intergrades into the Sedu Series (Histic Sulfaquept).

		pH		Conductivity		Exchangeable	
	Depth	Fresh	Incubated	Fresh	Incubated	meq Al^{3+}/100g	meq H^{+}/100g
PARIT	0–3 cm	3.45	3.30	100	190	11.13	2.63
BOTAK	8–27	3.30	3.30	145	170	12.29	3.10
(J.B. PERT.)	27–41	3.00	2.95	420	270	15.78	9.20
	41+	2.90	2.15	750	5400	24.2	11.1

% Sulfate-Sulfur (SO_4-S)			%	Exch.	Exch.	Exch.	Exch.		%
Total	2N-HCl soluble	Pyrite	N	Ca	Mg	K	Na	CEC	BS
				....		meq/100g	....		
0.12	0.07	0.05	0.67	2.94	0.61	0.26	0.16	32.15	–
0.14	0.09	0.05	0.33	2.81	0.49	0.19	0.14	32.15	–
1.17	0.19	0.08	0.26	0.49	0.79	0.16	0.14	35.72	–
1.99	0.32	1.67	0.23	0.55	1.7	0.26	0.22	28.93	–

Appendix (IV)

Location	:	Pilot Project, Pontian District, Johore
Grid Ref.	:	L7010 Series 133/675564
Topography	:	Flat coastal plain; about 1.5m asl.
Drainage	:	Imperfect
Water table	:	45 cm
Land use	:	Old coconut
Parent material	:	Marine alluvium
Classification	:	Serkat Series, Typic Sulfaquent

A1	0 – 3 cm	Black (10 YR 2/1) clay; moderate fine subangular blocky, friable, abundant fine and coarse roots; clear wavy boundary.
B21	3 – 8 cm	Brown (10 YR 5/3) clay; moderate medium angular blocky, sticky; few medium and fine distinct strong brown (7.5 YR 5/6) and few fine prominent yellowish red (5 YR 4/6) mottles; many fine and coarse roots; clear wavy boundary.
B22	8 – 22 cm	Grayish brown (10 YR 5/2) clay; weak coarse angular blocky; sticky; common coarse granular prominent yellowish red (5 YR 4/6) and common medium distinct, strong brown (7.5 YR 5/6) mottles; plentiful roots; many small shells present; clear wavy boundary.
B3g	22 – 42 cm	Blue grey clay; massive structureless; common coarse distinct strong brown (7.5 YR 5/6) mottles; few to plentiful roots; boundary gradual.
CG	42 cm +	Blue grey clay, massive structureless, sulfurous smell; many small shells present, few living roots.

		pH		Conductivity		Exchangeable	
	Depth	Fresh	Incubated	Fresh	Incubated	meq Al^{3+}/100g	meq H^{+}/100g
SERKAT	3–8 cm	7.20	6.80	80	225	0.05	0.13
SERIES	8–22	7.15	7.10	125	325	0.05	0.13
	22–42	6.00	4.75	400	1000	0.44	0.47
	42–54	6.15	3.80	620	2800	0.05	0.13
	54–80	7.35	7.10	900	1600	0.05	0.13

% Sulfate-Sulfur (SO_4-S) Total	2N-HCl soluble	Pyrite	% N	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	% BS
				. . . .	. . . .	meq/100g	. . . .	. . . .	
0.02	0.02	0.00	0.12	11.5	21.29	3.46	1.09	27.86	–
0.03	0.03	0.00	0.13	7.7	22.23	1.92	2.94	28.22	–
0.27	0.08	0.19	0.12	5.86	13.15	1.35	5.65	26.43	–
0.87	0.08	0.79	0.2	8.44	14.52	1.60	6.31	26.08	–
1.05	0.09	0.96	0.17	25.6	13.67	1.7	7.61	19.29	–

Appendix (V)

Location	:	Sg. Tongkang, near Rengit, Batu Pahat.
Grid Ref.	:	Series L7010 128/236037
Topography	:	Flat coastal plain
Drainage	:	Imperfect
Water table	:	54 cm
Land use	:	Old coconuts
Parent material	:	Marine alluvium
Classification	:	Selangor series, Shallow phase, Typic Tropaquept.

Ap		missing.
B21	0 – 14 cm	Dark grayish brown (10 YR 4/2) clay; moderate coarse angular blocky breaking down to moderate medium subangular blocky; friable-firm; few fine and medium roots, clear wavy boundary.
B22	14 – 37 cm	Light brownish gray (10 YR 6/2) clay; weak very coarse angular blocky; firm (sticky); abundant medium and coarse reddish brown (5 YR 4/4) and dark reddish brown (5 YR 3/4) mottles, clear wavy boundary.
II B3	37 – 54 cm	Very dark grayish brown, (10 YR 3/2) rich in organic matter, low bulk density apparent; structureless; few medium roots, boundary below water table not discernible.
CG		Sample taken from spoils, blue green clay, massive structureless.

		pH (H_2O)		Conductivity		Exchangeable		% Sulfate-Sulfur (SO_4-S)		
	Depth	Fresh	Incubated	Fresh	Incubated	meqAl^{3+} /100g	meqH^+/100g	Total	2N-HCl soluble	Pyrite
SG TONGKANG (Pit 3)	0–14 cm	4.80	4.80	60	125	1.55	0.62	0.08	0.06	0.02
	14–37	5.20	5.00	50	125	0.29	0.25	0.07	0.06	0.01
	37–54	4.00	3.70	195	675	4.94	1.40	0.15	0.08	0.07
	54–80	4.20	3.50	1200	3500	0.29	3.69	1.25	0.21	1.04

Depth	% N	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	% BS
		....	....	meq/100g	....	....	
0–14 cm	0.22	5.54	12.68	1.03	0.49	25.72	77.63
14–37	0.19	6.13	15.69	0.8	0.98	25.72	–
37–54	0.22	3.37	10.28	0.74	1.85	29.65	55.51
54–80	0.17	7.63	20.79	1.60	3.04	29.29	–

Discussion

Schlichting, E. (Germany): According to my observations in Malaysia, the land use problems on Bris soils should be distinguished according to the kind of soil (Regosols rich in lime or Podzols with a well developed spodic horizon).

Answer: I agree with you. As I described it in my paper, there are five different Bris soil series in Malaysia: 1) Rusila which is under waterlogged conditions without a spodic horizon; 2) Rudua where the spodic horizon is within 1m from the top; 3) Jambu and Baging, where the spodic horizon is below 1m and 4) the Rompin series with a clay content higher than that of the other four soils (7 – 10%). Soils with a high clay content have a better potential for crop production.

Kyuma, K. (Japan): You talked about controlled drainage on acid sulfate soils. I believe that controlled drainage is even more important on peat soils because of the subsidence problem. What is the planned depth of drainage when you reclaim peat soils?

Answer: I agree with you. For the acid sulfate soils, controlled drainage was designed to keep the pyritic layers waterlogged in order to minimize oxidation. By doing so, we normally utilize a virtually non pyritic top soil of a depth ranging between 15 to 20 cm for crop growth. As for the peat soils, the pilot project will investigate the effect of controlled drainage.

Kubota, T. (Japan); 1) You mentioned that cassava cultivation has recently been introduced on peat soils. How do the roots perform on woody peat soils? 2) Do you observe a significant leaching of phosphorus fertilizers on Bris soils? Do you have any data on the effect of sesquioxide application or dressing of lateritic soil on the efficiency of phosphorus fertilization?

Answer: 1) Although the performance of cassava on newly opened areas of peat is poor, good yields have been recorded on better developed peat. The main problem is the exposure of tubers. 2) Since tobacco is the most promising crop to be grown on Bris, several split applications of phosphorus fertilizers are carried out during the 13-week growth period of the crop. Leaching is a major problem due to the low CEC of this soil. On the other hand, I have no information on the effect of sesquioxide application or dressing of lateritic soil on the efficiency of phosphorus fertilization.

Umebayashi, M. (Japan): Could you indicate the name of the rice variety which is salt-tolerant and has been recommended to be planted on saline soils?

Answer: I do not know the name but I shall try to provide you with this information later on.

von Uexkull, H.R. (Singapore): Peat soils must be drained to grow crops. Drainage in turn speeds up oxidation. I wonder how long you can crop your peat soils before they become exhausted? Is it worthwhile to develop large areas of peat soils if after some decades of cropping the peat may be all used up? Is it not better to keep these soils under forest?

Answer: We would definitely prefer not to cultivate peat soils but due to population pressure we must use these soils which cover a large part of Malaysia (60% in the West Johore Pilot Project). We also know that oxidation proceeds rapidly (1 inch/year) but we hope that with a proper control of the water table and careful management we will be able to preserve our peat soils. In Malaysia we have two types of peat soils (7% of the total land area): the shallow peat soils overlying acid sulfate soils and the deep peat soils which are literally floating and which are carefully developed.

Hew, C.K. (Malaysia) Comment: We are fully aware of the problems created by the oxidation of peat soils and we would like to avoid it as much as possible.